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BOOK REVIEW

Davies, Dr. David (Rapporteur) *Seismic Methods for Monitoring Undergound Nuclear Explosions, an Assessment of the Status and Outlook*, International Institute for Peace and Conflict Research (SIPRI) Stockholm, Sweden 130 pp., 1968, $2.50.

This optimistic assessment of the status and outlook for the use of seismic methods to monitor underground nuclear explosions is timely, comprehensive, and competent. It is valuable for anyone interested in monitoring of underground nuclear explosions, whether seismologist or not, and gives background as well as current information necessary for adequate understanding of the problem. It is not a scientific treatise, but a consensus with a collection of scientific opinions from which the consensus was derived. In general it is clearly written—there is a certain amount of confusion introduced because the seismological discussion is primarily carried out in terms of magnitude, whereas the consensus statement only discusses yield. The study group responsible for the report consisted of a group of seismologists from Canada, Czechoslovakia, France, India, Japan, Romania, Sweden, the Union of Soviet Socialist Republics, the United Kingdom and the United States of America (Constantinescu, Ericsson, Herrin, Karnik, Mechler, Miyamura, Pasechnik, Press, Thirlaway, Whittam, Varghese). Dr. D. Davies, the Rapporteur, was responsible for much of the work of compiling the report.

The conclusions of the consensus of the report are well founded and important (and probably conservative):

(1) Seismic signals generated by undergound nuclear explosions of magnitude, m, greater than 4.75 and possibly as low as 4.0, can be *identified* (as explosions and not as earthquakes) as well as detected. The principal criterion for identification is the difference in relative excitation of long-period surface waves and short-period body waves. Other criteria such as depth, first motion, spectrum, and complexity, although not yet established as positive identification criteria, can be used as diagnostic aids.

(2) The limiting yield above which explosions can be identified by seismic methods (corresponding to $m = 4.75$) is about 20 to 60 kilotons for granite (crystalline rocks). Although this limit may be two to ten times greater for materials such as tuff and dry alluvium, it is considered to be unlikely that a sufficient thickness of dry alluvium could be found to contain explosions greater than 20 KT. Explosions can, to a limited extent, be hidden by reducing signal strength with large underground cavities, but this might be impractical for yields greater than about 10 KT. Routine identification of explosions as small as 10 KT in granite ($m = 4.5$) can be achieved with better equipment now becoming available, and eventually might be possible for explosions as small as 1–3 KT in granite ($m = 4.0$).

As more information becomes available, the assessment for use of seismic methods to monitor underground nuclear explosions appears to become more and more optimistic, and may have significantly improved even in the short time since the report was prepared. It appears that the major obstacle to a ban on large underground nuclear tests is political, not scientific. The report comes at a time of world-wide concern about nuclear proliferation. An underground nuclear test ban is closely related to nuclear proliferation—non-nuclear nations might be reluctant to sign a non-proliferation treaty if the nuclear nations continued their underground weapons testing programs. Perhaps the report will help to bring about a ban on underground nuclear tests and thus help to slow the world-wide race in weapons development.

The report lacks an adequate discussion of possible violations of an underground test ban. There is a curious naivete or contradiction in the statement beginning the three-paragraph section on violations of a treaty: "Although it is outside our scope to examine in detail the motives and means of violation, the group did take note of the possibility of violation and considered the seismological aspects of violation." This is a serious shortcoming since many opponents of a test ban hold that it must be assumed that opposing political factions would use all practical means to cheat on the ban. The possibility of hiding a nuclear explosion in an earthquake is only lightly touched on; it is agreed that on rare occasions, and at considerable risk, this might be done. Decoupling with large underground cavities or soft materials is suggested to be impractical for large explosions, although effective for small explosions.

Other limitations of the report stem largely from the circumstances in which it originated. It naturally represents the personal opinions of the limited number of seismologists involved, and many of these opinions can be questioned. However, this does not seriously detract from the

consensus statement. The consensus statement had to be acceptable to all the scientists in the group; scientists with different political backgrounds and different access to pertinent data (they were not acting in official capacities). To a certain extent the differences of opinion on particular points can be inferred from the main text of the report. Pasechnik (U.S.S.R.) is consistently more optimistic than Herrin and Press (U.S.). The report probably lacks some important data because of military classification and may well have expedited declassification and publication of some of these data. At any rate, it does not reflect certain recent research results now publically available from the U. S. Air Force Technical Applications Center and the U. S. Advanced Research Projects Agency. Consequently, it may have underestimated the importance of depth determinations, Love wave generation, and better techniques of surface wave analyses. The report does not consider recent observational results indicating that the source dimensions of small earthquakes are larger than previously supposed, results which further support the use of surface wave excitation to identify underground nuclear explosions.

The report consists of a consensus statement, a review of seismological principals, chapters on (1) detection and location of seismic events, (2) discrimination of earthquakes and explosions and (3) conclusions. There are eight appendices on technical matters including decoupling, amplitude versus yield, complexity and historical setting. Topics considered also include: seismic noise, borehole seismographs, underwater seismographs, seismic arrays, detection probability, location of earthquakes, earthquake statistics and international data exchange.

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